

May 30, 2000

TO: University of Utah, Mechanical Engineering Department  
Graduate Studies, Attn: Dr. J. Klewicki

FROM: J. R. C. Heman, Thiokol Propulsion  
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SUBJECT: Statement of Purpose – Masters of Science Degree in Mechanical Engineering

I have completed 43 hours of graduate course work through the University of Utah/Thiokol Propulsion agreement under the quarter system. I have applied to graduate school to perform the work to obtain a Masters of Science in Mechanical Engineering for Fall Semester 2000. I also completed my undergraduate degrees in Mathematics and Mechanical Engineering at the U of U from 1981 through 1988. I have been employed with Thiokol since my graduation from the university. Due to a variety of issues both work related and personal, I have not as yet completed my graduate studies. I am submitting the following technical subject for consideration as a thesis topic for the master degree:

The reusable solid rocket motor (RSRM) nozzle internal joints are being evaluated for the incorporation of a carbon fiber rope (CFR) as a thermal barrier (Figure 1). The CFR is approximately 0.260" diameter and is composed of approximately 12,000 carbon fibers, woven in ten sheaths or layers (Figure 2). The CFR is manufactured by a sub-tier vendor and subsequently several of its manufacturing details are proprietary to that vendor. The CFR design intent is to prevent hot motor combustion products and slag from intruding into the joint sealing area while still approaching a vented joint design to avoid the detriments of gas jet impingement.

As a member of the Heat Transfer section at Thiokol Propulsion, two main goals exist as part of this NASA funded design effort:

- (1) development of flow model through the CFR and
- (2) development of a heat transfer model through the CFR.

While both models are needed and most probably interrelated, the gas flow model is being targeted as the subject matter. Essentially, the topic would be "Modeling of Gas Flow through a Braided Carbon Fiber Rope". An AIAA journal or conference paper is being considered through Thiokol/NASA as well.

A sub-scale CFR flow test fixture (Figure 3) was designed to simulate the relative levels of CFR compression. The test fixture provides the means to measure gas mass flow rate upstream of the CFR and the pressure and temperature both upstream and downstream of the CFR. The test fixture was designed to eliminate the possibility of dynamic gapping at the CFR location and provide minimal flow resistance to ambient for gases exiting the rope. The data collected in the experiment will be evaluated to define a permeability/flow resistance model. The design work for the test fixture was completed by myself and Dr. Mark Ewing, Thiokol Propulsion.

Two possibilities exist for the flow characteristics through the CFR from choked flow to strictly friction driven. A test matrix for evaluating the CFR has been compiled, which addresses both of these characteristics. The range of pressures to be tested covers a relatively low delta pressure where non-choked flow is impossible, while the high pressure shown is dictated by the RSRM joint operating pressure where choking is possible. The test matrix, Table 1, was also designed for a range of rope compressions or test fixture gaps ranging from 0.025" to 0.070". These gaps are controlled by the range of RSRM full-scale hardware joint gaps that will be expected by virtue of the joint design.

I would appreciate your consideration of this statement of purpose for attaining a Masters of Science degree in Mechanical Engineering. Please feel free to contact the undersigned if you have any questions regarding the information provided.

Sincerely,

J. R. C. Heman

Figure 1 RSRM Nozzle Internal Joint 2 – Preliminary Rope Design Concept

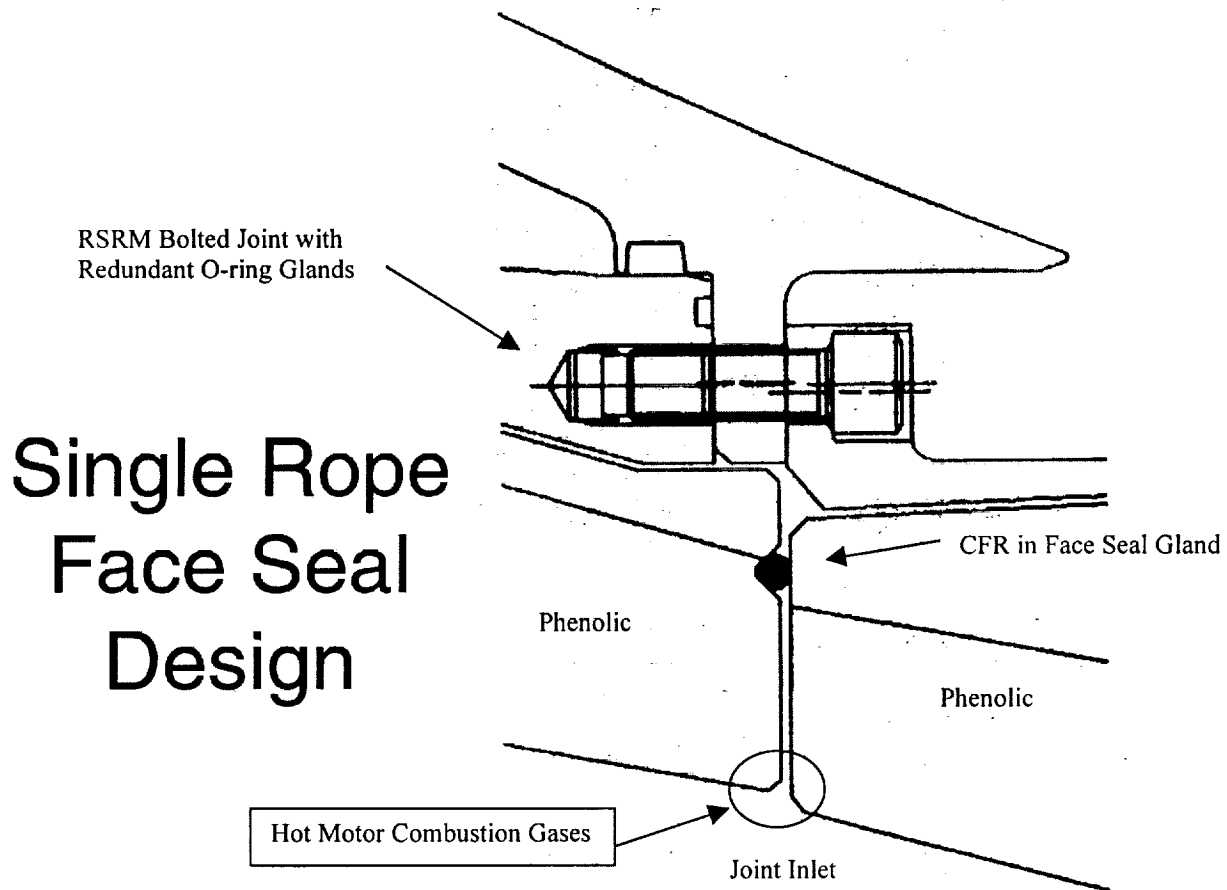
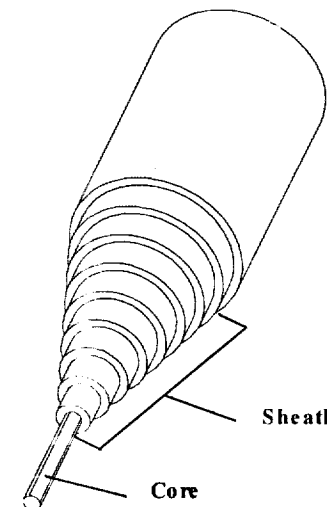


Figure 2 Carbon Fiber Rope Physical Data

General Details	Rope Diameter	0.260 inches
	Fiber Material	Thornel T-300
	Fiber Diameter	$2.76 \times 10^{-4}$ inches
Core Details	Fiber Count	12 K
Sheath Details	Number of Sheaths	10
	Number of Carriers per Sheath	8 (sheath 1-5) 12 (sheath 6,7) 16 (sheath 8-10)
	Fiber Count per Carrier	1K (sheath 1-3) 3K (sheath 4-10)
	Braid Angle	0° (Core) 17° (sheath 1) 45° (sheaths 2-10)



The diagram shows a cross-section of a carbon fiber rope. It consists of a central core and ten concentric sheaths. The core is labeled 'Core' and the sheaths are labeled 'Sheaths'. The rope is shown in a perspective view, tapering from left to right.

Figure 3 CFR Permeability Test Fixture (Preliminary)

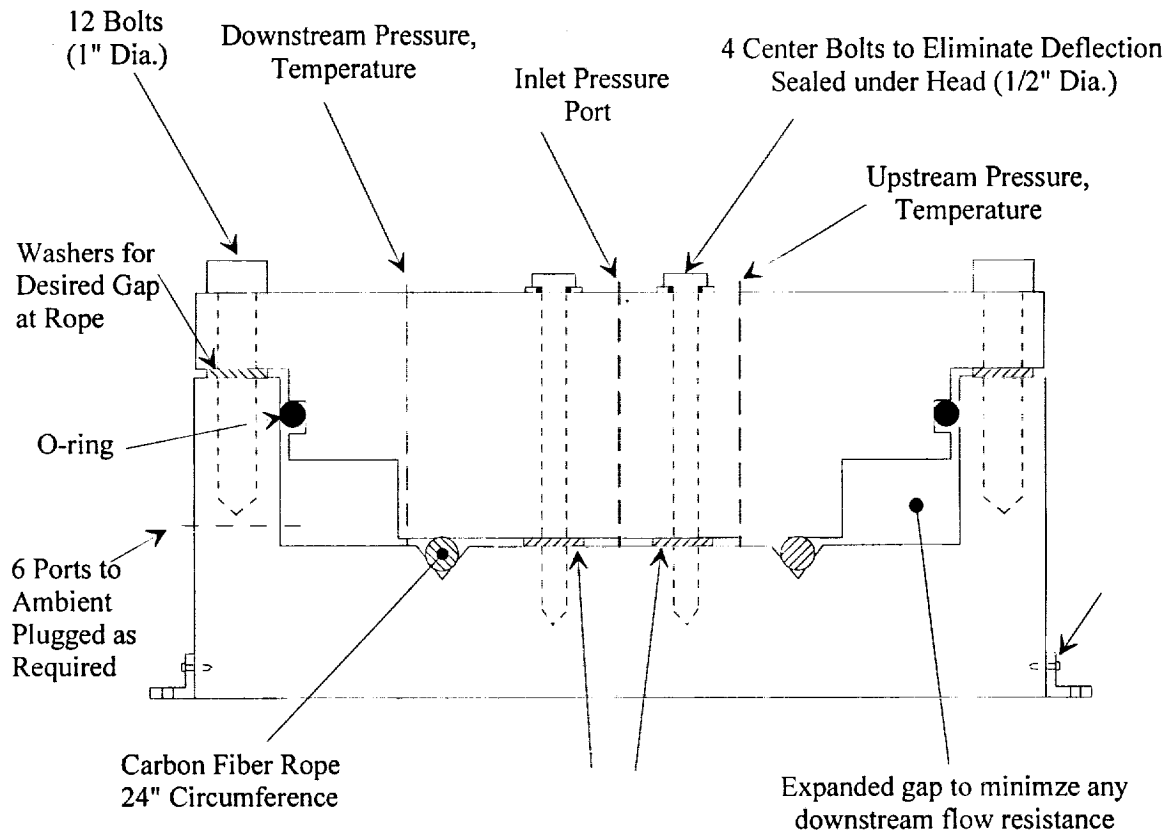


Table 1 Permeability Test Matrix – NASA Approved Test Plan

Target Gaps <sup>1</sup> (in)	Pressure (psig)	Repetitions at Each Pressure	Comments
↓	0.070	2	Steady-state flow control
	0.065	7	
	0.050	12	
	0.045	100	Instantaneous pressurization
	0.030	500	
	0.025	900	

- 1 Starting from highest gap proceeding to lowest gap successively testing a single rope at higher compression levels ⇒ Only requires 3 sections of rope.